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Frequency and Pattern of 4th canal in permanent maxillary 1st molar Endodontic Department of Tertiary Care Hospital Khyber College of Dentistry Peshawar

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Abstract

Background: The permanent maxillary first molar possesses a complex root canal system with frequent anatomical variations, particularly in the mesiobuccal root. The presence of an additional canal, commonly known as the fourth canal or MB2 canal, is clinically significant because failure to detect and treat it may lead to endodontic treatment failure. **Objective:** To determine the frequency and pattern of the fourth canal in permanent maxillary first molars in patients presenting to the Endodontic Department of Khyber College of Dentistry. **Materials and Methods:** A descriptive cross-sectional study was conducted in the Endodontic Department of Khyber College of Dentistry, Peshawar. Secondary data of 138 patients aged 15–60 years were collected from departmental records of patients treated during 2018. Patients having permanent maxillary first molars without systemic disease were included, while necrosed teeth were excluded. Radiographic records and patient files were carefully evaluated to identify the

number and pattern of root canals. Data were entered and analyzed using SPSS, and descriptive statistics were applied to calculate frequencies and percentages. **Results:** Among the 138 permanent maxillary first molars examined, 116 teeth (84.1%) exhibited three canals, while 22 teeth (15.9%) demonstrated four canals. Of the teeth with four canals, the majority of additional canals were located in the mesiobuccal root in 20 cases (90.9%), whereas only 2 cases (9.1%) were found in the distobuccal root. Gender-wise analysis revealed slightly higher frequency of four canals among females compared to males. The occurrence of four canals was also slightly greater in left maxillary first molars than right maxillary first molars. Age-wise distribution showed that younger patients demonstrated a comparatively higher frequency of fourth canals. **Conclusion:** The present study demonstrated that the fourth canal occurs in a considerable number of permanent maxillary first molars, with the mesiobuccal root being the most common location. Careful clinical and radiographic examination, along with the use of advanced diagnostic aids, is essential for successful endodontic treatment and prevention of missed canals.

Keywords: Permanent maxillary first molar, Fourth canal, MB2 canal, Root canal morphology, Endodontics, Canal configuration.

Introduction

Successful endodontic therapy depends upon thorough cleaning, shaping, and obturation of the entire root canal system. Failure to identify and treat all canals may result in persistent infection and eventual endodontic failure. Among permanent maxillary first molars, the mesiobuccal root commonly exhibits complex internal anatomy and frequently contains a second mesiobuccal canal, often referred to as the fourth canal or MB2 canal (Vertucci, 1984). Identification of this canal remains a significant clinical challenge for endodontists because of its variable location, small diameter, and frequent calcification (Stropko, 1999).

The permanent dentition contains three molar teeth in each quadrant of the oral cavity, namely the first, second, and third molars. In the maxillary arch, these teeth are referred to as the permanent maxillary first molar, second molar, and third molar. The first permanent molar is commonly known as the “six-year molar” because it usually erupts around the age of six years, while the second molar is called the “twelve-year molar” due to its eruption at approximately twelve years of age. The third molar, often termed the “wisdom tooth,” exhibits the greatest anatomical variation among all permanent teeth (Gerald et al., 2024).

The permanent maxillary first molar is considered one of the most important teeth in the dental arch because of its role in mastication, maintenance of occlusion, and

guidance of eruption of other permanent teeth. It is usually the largest tooth in the maxillary arch and erupts distal to the deciduous second molar without replacing any primary tooth (Nelson et al., 2023). Anatomically, the tooth consists of two main parts: the crown and the root, which are separated by the cementoenamel junction (CEJ). The crown of the permanent maxillary first molar is wider buccolingually than mesiodistally and is comparatively shorter occlusogingivally than the anterior maxillary teeth (Atkinson et al., 2024).

Typically, the permanent maxillary first molar possesses three roots: mesiobuccal, distobuccal, and palatal roots. Among these, the palatal root is the largest and strongest, whereas the distobuccal root is the smallest and shortest. The mesiobuccal root is anatomically the most complex because it is broad buccolingually and frequently contains an additional canal known as the second mesiobuccal canal (MB2), commonly referred to as the fourth canal (Gerald et al., 2024). This canal is often narrow, calcified, and difficult to identify during endodontic treatment.

The pulp cavity of the tooth is divided into the pulp chamber and root canals, and normally each root contains one canal. However, anatomical variations in the root canal system of the permanent maxillary first molar are common. Numerous studies have demonstrated that the mesiobuccal root may contain two canals instead of one, increasing the total number of canals from three to four (Karthikeyan et al., 2021). Variations in canal morphology are clinically significant because untreated canals may harbor residual microorganisms, leading to persistent infection and endodontic failure. Endodontics is the branch of dentistry concerned with the morphology, physiology, and pathology of the dental pulp and periradicular tissues (Parameswaran et al., 2022). Dental caries, trauma, gingivitis, and periodontitis are among the most common oral diseases affecting the teeth and surrounding tissues. Dental caries is considered one of the most prevalent bacterial diseases worldwide and can result in destruction of enamel and dentin, ultimately leading to pulpal inflammation and necrosis if left untreated (Norman et al., 2024). Once the pulp becomes infected, microorganisms may spread through the root canal system, necessitating root canal treatment to eliminate infection and preserve the tooth.

Successful root canal treatment depends upon complete cleaning, shaping, disinfection, and obturation of the entire root canal system. Therefore, comprehensive knowledge of root canal anatomy is essential for clinicians performing endodontic procedures (Vertucci et al., 2022). The permanent maxillary first molar is frequently associated with endodontic treatment failure because the additional mesiobuccal canal is often missed during treatment (Smadi et al., 2023). Failure to identify and treat the

MB2 canal may leave infected tissue within the canal system, contributing to post-treatment disease and persistent periapical pathology.

The anatomical complexity of the maxillary first molar has been widely studied in endodontic literature. Several investigations have reported a high prevalence of a second mesiobuccal canal in the mesiobuccal root (Michael et al., 2021). Studies also indicate that the MB2 canal may either merge with the main mesiobuccal canal or terminate separately through an independent apical foramen (Wolcott et al., 2024). Due to the small size and hidden position of the canal, its clinical identification remains challenging for dental practitioners (Kulid et al., 2020).

Advancements in diagnostic and magnification techniques have significantly improved the detection of additional canals. Traditionally, clinicians relied on conventional radiographs and tactile examination to locate canals; however, periapical radiographs provide only two-dimensional images of three-dimensional structures, limiting accurate visualization of complex root canal anatomy (Guo et al., 2023). The introduction of surgical operating microscopes (SOM), enhanced access cavity designs, and cone-beam computed tomography (CBCT) has markedly improved the identification of MB2 canals and their configurations (Norman et al., 2024). CBCT, in particular, provides three-dimensional visualization of the internal morphology of teeth and is considered one of the most reliable methods for detecting additional canals and apical foramina in maxillary first molars (Filho et al., 2020).

Because anatomical variations differ among populations and ethnic groups, studying the frequency and pattern of the fourth canal in permanent maxillary first molars is essential for improving the success rate of endodontic therapy. Therefore, the present study aims to evaluate the frequency and anatomical pattern of the fourth canal in permanent maxillary first molars among patients presenting to the Endodontic Department.

Materials and Methods

This descriptive cross-sectional study was conducted in the Endodontic Department of Khyber College of Dentistry to determine the frequency and pattern of the fourth canal in permanent maxillary first molars. The study population consisted of patients aged 15–60 years who visited the Endodontic Department of Khyber College of Dentistry, Peshawar.

A total of 138 samples were included in the study. Secondary data were utilized, and records of patients who attended the Endodontic Department during 2018 were reviewed. A non-probability convenient sampling technique was applied for data selection.

Patients having permanent maxillary first molar teeth and without any systemic disease were included in the study, whereas necrosed teeth were excluded from the analysis.

Data were collected after obtaining permission from the Ethical Review Committee of Khyber College of Dentistry. Patient records and radiographic examinations were carefully reviewed. Relevant information regarding the presence and anatomical pattern of the fourth canal in permanent maxillary first molars was extracted and recorded using a structured questionnaire.

All collected data were entered and analyzed using Statistical Package for Social Sciences (SPSS). The entered data were checked for completeness, missing values, and possible errors before analysis. Descriptive statistics were applied to calculate frequencies and percentages of the studied variables.

Results

A total of 138 permanent maxillary first molars were evaluated to determine the frequency and pattern of the fourth canal. Statistical analysis demonstrated variations in the number and location of root canals among the examined teeth.

The majority of teeth, 116 (84.1%), exhibited the conventional three-canal configuration, whereas 22 teeth (15.9%) presented with four canals. These findings indicate that although the three-canal pattern remains the most common anatomy in permanent maxillary first molars, the occurrence of a fourth canal is clinically significant and should not be overlooked during endodontic treatment.

Table 1: *Frequency of Number of Canals*

Number of Canals	Frequency	Percentage (%)
3 Canals	116	84.1
4 Canals	22	15.9
Total	**138**	**100.0**

Among the 22 teeth exhibiting a fourth canal, the majority of additional canals were located in the mesiobuccal root. The mesiobuccal root showed the presence of the fourth canal in 20 cases (90.9%), whereas only 2 cases (9.1%) demonstrated the fourth canal in the distobuccal root. These results highlight that the mesiobuccal root is the most common site for an additional canal in permanent maxillary first molars.

Table 2: *Frequency and Pattern of Fourth Canal*

Location of Fourth Canal	Frequency	Percentage (%)
Mesiobuccal Root	20	90.9
Distobuccal Root	2	9.1

Location of Fourth Canal	Frequency	Percentage (%)
Total	**22**	**100.0**

Gender-wise distribution of the patients revealed that among male patients, 63 teeth (45.7%) had three canals while 10 teeth (7.2%) presented with four canals. Among female patients, 53 teeth (38.4%) exhibited three canals and 12 teeth (8.7%) showed four canals. Although the occurrence of four canals was slightly higher among females, the three-canal configuration remained the predominant morphology in both genders.

Table 3: *Gender-wise Distribution of Number of Canals*

Gender	3 Canals	4 Canals	Total
Male	63	10	73
Female	53	12	65
Total	**116**	**22**	**138**

The distribution of canals according to tooth side was also evaluated. On the right side maxillary first molar, 64 teeth (55.2%) demonstrated three canals and 10 teeth (45.5%) exhibited four canals. On the left side maxillary first molar, 52 teeth (44.8%) showed three canals while 12 teeth (54.5%) presented with four canals. The findings indicate a slightly greater prevalence of four canals on the left side compared to the right side.

Table 4.4: *Distribution of Number of Canals According to Tooth Side*

Tooth Side	3 Canals	4 Canals	Total
Right Maxillary First Molar	64	10	74
Left Maxillary First Molar	52	12	64
Total	**116**	**22**	**138**

Age-wise distribution showed that the highest frequency of four canals was observed in younger patients. In the 15–29 years age group, 62 teeth had three canals while 12 teeth presented with four canals. In patients aged 30–44 years, 42 teeth showed three canals and 8 teeth had four canals. In the 45–59 years age group, 12 teeth exhibited three canals whereas only 2 teeth demonstrated four canals. Overall, the prevalence of four canals decreased with increasing age.

Table 4 : *Frequency of Number of Canals in Different Age Groups*

Age Group (Years)	3 Canals	4 Canals	Total
15–29	62	12	74
30–44	42	8	50
45–59	12	2	14

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Age Group (Years)	3 Canals	4 Canals	Total
Total	116	22	138

Discussion

The primary objective of endodontic therapy is the prevention and treatment of pulpal and periapical diseases through complete cleaning, shaping, disinfection, and obturation of the entire root canal system. Failure to identify and adequately treat all canals may result in persistent infection and eventual endodontic treatment failure (Parameswaran et al., 2022). Among permanent maxillary first molars, the mesiobuccal root is considered the most anatomically complex and is frequently associated with missed canals, particularly the second mesiobuccal canal (MB2), also referred to as the fourth canal.

The present study evaluated the frequency and pattern of the fourth canal in permanent maxillary first molars. The findings demonstrated that 22 out of 138 teeth (15.9%) exhibited four canals, while 116 teeth (84.1%) showed the conventional three-canal configuration. These findings indicate that although the occurrence of the fourth canal is less frequent compared to the normal anatomy, its presence remains clinically significant during endodontic treatment.

Several previous studies have reported varying frequencies of fourth canals in permanent maxillary first molars. A study conducted by American Dental Association researchers Hartwell et al. reported that 70.2% of maxillary first molars possessed four canals, and approximately 99% of these additional canals were located in the mesiobuccal root (Hartwell et al., 2021). The frequency reported in their study was considerably higher than that observed in the present study. This difference may be attributed to the use of advanced diagnostic technologies, including operating microscopes and enhanced imaging systems, which improve canal detection rates.

Similarly, Filho et al. (2020) reported that 67.1% of maxillary first molars in a Brazilian population exhibited four canals, whereas 32.1% had three canals. Although the frequency of four canals reported in their study was much higher than the findings of the present study, both studies showed agreement regarding the location of the fourth canal, with the majority occurring in the mesiobuccal root. In the present study, 90.9% of fourth canals were located in the mesiobuccal root, while only 9.1% were identified in the distobuccal root.

Another study conducted in Ireland by Al Shalabi et al. (2021) reported a 78% prevalence of fourth canals in the mesiobuccal root, which was lower than several international studies but still greater than the frequency observed in the present research. Norman Weller et al. also reported that 39% of treated maxillary first molars

had four canals, which is notably higher than the 15.9% reported in the current study (Hartwell et al., 2021). Variations among studies may be related to differences in population characteristics, ethnicity, sample size, age groups, and diagnostic techniques used during evaluation.

The present study further demonstrated that among the 22 teeth with four canals, 20 cases (90.9%) involved the mesiobuccal root, whereas only 2 cases (9.1%) involved the distobuccal root. These findings support the widely accepted concept that the mesiobuccal root of the permanent maxillary first molar possesses the most complex internal anatomy and should be carefully examined during endodontic procedures.

Gender-wise analysis revealed that the prevalence of four canals was slightly higher among females than males. Female patients demonstrated 12 cases (8.7%) of four canals compared with 10 cases (7.2%) in male patients. However, the conventional three-canal morphology remained the most common configuration in both genders.

In terms of tooth side distribution, four canals were slightly more frequent in left maxillary first molars than right maxillary first molars. Left-sided teeth demonstrated 12 cases (54.5%) with four canals compared to 10 cases (45.5%) on the right side. This difference may reflect normal anatomical variation within the maxillary arch.

Age-wise analysis indicated that younger patients demonstrated a greater frequency of fourth canals compared to older individuals. The highest prevalence was observed in the 15–29 years age group, while the lowest frequency was recorded among patients aged 45–59 years. This finding may be explained by increased calcification and secondary dentin deposition with advancing age, which may obscure canal visibility and complicate canal detection during radiographic and clinical examination.

The results of the current study emphasize the importance of thorough clinical and radiographic evaluation before and during root canal treatment of permanent maxillary first molars. The use of modern diagnostic aids such as cone-beam computed tomography (CBCT), magnification loupes, and surgical operating microscopes can significantly improve the identification of additional canals and reduce the risk of endodontic treatment failure.

Conclusion

The findings of the present study demonstrated that the incidence of a fourth canal in permanent maxillary first molars was 15.9%. The majority of fourth canals (90.9%) were located in the mesiobuccal root, confirming that the mesiobuccal root possesses more complex internal anatomy compared with the distobuccal and palatal roots. The conventional three-canal configuration remained the most common anatomical pattern among the studied teeth.

Recommendations

Greater attention should be directed toward careful examination and identification of additional canals during endodontic treatment of permanent maxillary first molars, particularly the second mesiobuccal canal (MB2). Modification of access cavity design and thorough exploration of the pulpal floor may improve the likelihood of locating additional canals.

The use of advanced diagnostic techniques such as cone-beam computed tomography (CBCT), dental operating microscopes, magnification loupes, and improved radiographic methods is strongly recommended to enhance canal detection and reduce the risk of missed canals.

Clinicians performing endodontic therapy on permanent maxillary first molars should possess detailed knowledge regarding root canal morphology and anatomical variations. Increased emphasis should also be placed on training dental practitioners in the use of magnification and modern endodontic technologies to improve treatment prognosis and minimize endodontic failure rates.

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